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STANDARD GAUGE

AND

NARROW GAUGE:

A

POPULAR DISCUSSION OF THE RELATIVE ADVANTAGES OF THE STANDARD AND THE NARROW GAUGE FOR LIGHT LOCAL RAILROADS.

BY BARON M. M. VON WEBER,

Councillor of the German Empire.

TRANSLATED FROM THE GERMAN.

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INTRODUCTION

The work of Weber here presented is wholly popular in its character, citing very few figures and facts in evidence of the statements made; but it is as far as possible from being an *a priori* argument—a deduction from general principles made by the mind of the author. For the work is only a popular expression of facts ascertained by observation and experience and set forth at length in other longer works of the author, addressed to the engineering profession. And perhaps no man living has taken greater pains to arrive at the facts—to learn just what the experience with light railroads of different gauges has been in Europe. It must be borne in mind that narrow-gauge railroads are not a novelty there. There is a considerable number of them more than twenty years old, including one of the very first railroads built in Belgium. The novelty is not in the roads but in the wide-spread advocacy of their narrow gauge in recent years. In Weber's list of materials and in preparing this pamplet, after naming the 55 different works examined, he cites the following investigations of his own:

"Visit to and study of the Norwegian narrow-gauge roads, July, 1865.

"Second visit to and study of the extended system of the Norway roads, August, 1873.

"Visit to and study of the Swedish standard and narrow-gauge roads, August, 1868.

"Second visit to the same roads, August, 1873.

"Visit to and study of the Festiniog Railway, in July, 1870, and August, 1872.

"Visit to and study of the Antwerp & Ghent Railroad, August, 1872.

"Many observations of the Bröhlthal Railroad in several years."

In his work on "Experience with Secondary Railroads in Europe" he has described these and most of the

other narrow-gauge railroads then existing in Europe, their rolling stock and the results of their operations quite minutely and with full statistics, and in it he bases all his statements on the actual experience of these roads as they were, and not on what they might, could, would or should have been.

We mention this because in this country, where the eminent author is not very widely known (his elaborate "Experiments on the Stability of Permanent Way" were translated and published in *Engineering* and the *Railroad Gazette*, and are pretty well known to American engineers as the most complete investigation of that subject), it might be supposed that his convictions on this subject, like those of too many other persons, were the result of prejudice, or of "reasoning from general principles," instead of being founded upon observation and experience.

As to the regard paid to Baron von Weber's views on this subject in Germany, it is enough to say that when, a year or more ago, it was proposed to encourage the construction of a great number of local railroads, to be cheaply built, in Prussia, largely to be undertaken by the municipalities assisted by the government of the Kingdom, he, then a resident of another empire, was called upon to prepare a general report on the subject, which has since been published in a pamphlet; and afterward he was called to a position in the Prussian Ministry of Trade, where he is to supervise the establishment of this system of secondary railroads, which will probably be greater than any now existing. It is evident, then, that the author's name carries weight where he is best known, and that he is regarded especially as an expert in the particular subject which he has here treated.

The difference between the methods of construction of railroads, and especially of their equipment, in Europe and America is such as to make some statements of Weber's discussion entirely inapplicable in this country. This is especially true of the practicable limit of the radius of curves. The statement of the

Swedish engineers that where curves need be of no smaller radius than 1,300 ft. the cost of road construction is substantially the same for the standard and the narrow gauges is in this country equivalent to the statement that nowhere need there be a difference in the cost; for curves of a quarter of that radius can be found on many standard-gauge roads here, and, as we have said in a foot-note, the largest traffic in America, some 600 trains daily, is over a railroad of standard gauge (the Metropolitan Elevated, in New York city), with curves of only *ninety* feet radius.

There are some other statements in the work translated which deserve extended comment, in order to show their applicability or inapplicability to American practice, but circumstances have made it impossible at this time. It is given as the expression of one of the ablest, most experienced and best informed of European engineers and railroad men on a subject which had there become one of the greatest practical importance, after a most thorough examination of the facts of experience on nearly all the narrow-gauge roads which have been long in operation.—THE TRANSLATOR.

STANDARD GAUGE

AND

NARROW GAUGE.

BY BARON M. M. VON WEBER.*

I.

TWO CARDINAL QUESTIONS.

By reason of the railroad programme of the Imperial Government, which includes designs from several secondary railroads, among them some with a gauge narrower than the standard, two questions of importance to the whole technical and economical development of railroad business have again come to the front for discussion.

The first of these questions is:

Are there advantages to be gained in the economy of the construction and operation of railroads by the reduction of their gauge, and of what kind and especially how great are they?

The second is a consequence of the first:

* Formerly for many years manager of the Government Railroads of Saxony, afterward Consulting Expert in Railroad Matters for the Austrian Government, and recently appointed Imperial Councillor and called to Berlin to an office in the Ministry of Commerce and Public Works, where he has the supervision of the establishment of a great system of secondary railroads to be constructed in Prussia. His experience in railroad service extends over some 30 years. In the preparation of his larger work on "Experience with Secondary Railroads in Europe," he visited, examined and reported quite minutely upon nearly every narrow-gauge and other light railroad in Europe, some of which are among the oldest on the continent, and all his statements are backed by the actual facts in the experience of these roads, which he has recorded in this larger work. Weber is universally recognized in Europe as one of the ablest of railroad men, and he is probably the very first of German writers on railroad affairs, general as well as technical.—THE TRANSLATOR.

Which gauge, standard or narrow, is best suited for the construction of railroads of secondary importance, or of especially local interest?

Both questions have already been treated exhaustively in the technical and scientific world and literature. On account of their nature, however, these discussions could not be within the comprehension of the general public, which indeed includes the circles and factors of the state which decide the railroad policy.

Therefore the general opinions in this matter remain conflicting and indefinite. But it is now time to view these questions, free from the formulas and jargon of science, and, having propounded them clearly and objectively, to explain them briefly and in a popular manner to the sound human reason, in order that mistakes make be avoided which it would be hard to repair.

The author, who has prepared most practical discussions of the subject, and circulated them in the technical world,† may properly consider himself qualified for such an exposition. He choses for it the form most generally intelligible, when necessary for clearness—the catechetical form. He requires no "faith" for his statements, for he expresses no subjective opinions, but he requests an objective observation and examination for the facts which he reports.

The question whether standard or narrow gauge, is no more to be answered on general principles than the question whether a "way" should be narrow or wide. A "foot-way" would "properly" be narrow; a "highway" wide.

The objects of the railroads, the differences in the

† M. M. von Weber: Die Praxis der Baues und Betriebes der Secundärbahnen mit schmaler und normaler Spur, etc. Weimar, Voigt, 1873. (Experience in the Construction and Operation of Secondary Railroads with Narrow and Standard Gauge.)

Die Individuälisirung und Fortentwickelbarkheit der Eisenbahn, 1875. Leipzig, Teubner. (The Individualization and Development of the Railroad.)

Neue Pfade der Volkswirthschaft. (New Paths of National Economy.) Die Secundärbahnen, etc. (The Secondary Railroads, etc.) Weimar, Voigt, 1874.

Nationalität und Eisenbahn-Politik. (Nationality and Railroad Policy.) Vienna, Hartleben, 1875.

traffic required of them, the difficulties encountered in their construction, are just as various as those of the different kinds of common roads which are included between the foot-path and the highway.

The standard gauge is just as appropriate as the narrow gauge, each in its place. A road which carries nothing but coal, stone, timber, ore, or at most has a few slow passenger trains, must everywhere be considered differently from another over which a dozen express trains rush back and forth daily—if both are to be constructed economically, in accordance with their nature.

The question: What specific advantages will result from the adoption of the standard or narrow gauge in the construction of a railroad, disowns this gospel of all economy. This question places the matter in a wrong light, because in discussing it things which have nothing in common are forced to a comparison. Some one takes statistics, deduces averages of the cost of construction and working expenses of great trunk lines, and compares these with the expenditures for construction and operation of a secondary railroad meandering through difficult ground, with a slow traffic, and concludes straightway that those trunk lines could have been properly built just as cheaply as these latter if only the same method of construction had been adopted. A full-blooded horse and a donkey belong to the same genus of animals, and each in its way is a very valuable creature, but their services can no more be compared than their cost.

In fact, only those roads should be compared as to economy of construction and operation on which the requirements of traffic, in regard to amount, frequency, speed and nature, are, at least in the main, the same.

How far the gauge of the lines under consideration exercises an influence is the first question, to which the following brief discussion is devoted. In this, only those secondary roads can be meant which have to carry both passengers and freight. The discussion of

the question does not extend to all grades of local roads, from the track on which the mine cars run into the adit to the line which connects an elegant bathing resort to a main line.

The so-called "standard gauge" of railroads (4 ft. 8½ in.) is not the result of technical investigations, but occurred entirely by chance, because the first roads with tracks in the North of England were made to fit the usual gauge of the wagons used there for carrying coal on the highways.

Nothing is more natural, then, than that in the early days of railroads, when no one could have any idea of such a connection of lines and net-works as the railroad map shows to-day, there should be deviations from this accidental measure, and always in favor of larger dimensions. In England, Ireland, America, etc., great systems of lines were established with wider gauge; Russia, Spain, Holland, Baden, etc., etc., adopted such gauges as their standards.

In this way many advantages in construction were attained. But when the connection of the system was completed, and the passage of freight through on the same car became a requisite to economy in freight traffic and comfort in passenger traffic, the break of gauge became impossible, and all European lines and states (with the exception of isolated Spain, and of Russia, which on account of its great extent assumes to act independently) hastened, with enormous expense and difficulty, to change their roads to the standard gauge.

A great statesman thus designated briefly three unities as fundamentals of the world's traffic: money, weights and measures, and railroad gauge.

The economical disadvantages which had been demonstrated by the construction of lines wider than the standard gauge (especially when the width was too great, as, for example, the 7 ft. of the Great Western Railway in England, the 6 ft. in Holland, etc.) led to the extreme.

An inverse conclusion was made, that, just as much

as the wider gauge roads had been too dear, those with a narrower gauge must be cheaper than the standard.

The construction of lines was begun whose traffic must be intended to be isolated for all time from the traffic of the world, or whose freights were of such a nature that the cost of transferring them would seem to be more than balanced by the saving in construction over the cost of a standard-gauge road; or systems were begun whose extent and the traffic common to them seemed to guarantee them an almost independent existence; and finally lines were planned where, either by the utilization of the highways for the construction of the roads, or by other local circumstances, peculiar advantages were connected with the use of the narrow gauge.‡

Thus were produced the Swedish and Norwegian narrow-gauge roads, the Festiniog Railway in England, the Antwerp & Ghent Railroad in Belgium, the Bröhlthal road in Rhenish Prussia, the narrow-gauge system in Upper Silesia, the Lambach & Gmunden road in Austria, a few new lines in France, and short railroads in Switzerland, aside from a number of lines for the use of great industrial establishments, whose circumstances are entirely different from those of public railroad interests, and exclude comparison with public roads, although their extent, as at Reschitza, Essen, Dortmund, Creusot, etc., includes many kilometers.

On several of the above lines which, on account of their isolation, the variation from the standard gauge had been found economical, it disappeared through connections and before unexpected interchanges of traffic.

The reconstruction of the Swedish narrow-gauge roads, which connect the great seas, apparently situated where they were unapproachable, became necessary when transfer ferry boats were established to

‡ In France, in the latter years of Napoleon's reign, an administrative and financial principle, the protection of "the monopoly of the great railroads," also became the motive for the adoption of the narrow gauge for certain railroads. We will mention this further hereafter.

carry over cars; that of the Lambach & Gmunden road arose from the effect of the extension of the line; and the operation of the narrow-gauge roads in Upper Silesia was long ago changed from locomotives to horses, the former being found uneconomical.

In the civilized countries of Europe, the narrow-gauge system, in its application for public use, on the basis of the experiments made with and on the above-named lines, has found no further diffusion; on the contrary, it is being continually restricted.

It is different in the wide territories of other continents, where there are immense distances between the connections, the population is comparatively thin, and makes slight demands for accommodation and prompt transportation, and all the ideas of a dawning civilization make quite different demands on the engineering economy of the railroads than in the highly cultivated countries of Europe. There in the Western, Southern, and Central states of America, in the East Indies and Australia, in parts of Russia, etc., narrow-gauge railroad systems have been developed of so great extent and of so distinct traffic relations that each, for the present, may be considered as independent, and its method of construction be chosen without regard to that of other roads. There the narrow-gauge system has found development with half a dozen different gauges. Whether this policy will be shown to be a mistake to the railroad proprietors who have considered only the present circumstances, remains to be seen. At any rate, the circumstances of those countries are too much unlike ours to make it advisable to be guided by their results.

II.

CHARACTERS OF THE SYSTEMS.

In order to secure a just standard for the examination of the general advantages and disadvantages which would result from the application of the narrow-gauge (say one meter, or 3 ft. 3⅜ in.) in this country, we must ask ourselves a few questions in re-

gard to the peculiarities of the system on which those advantages and disadvantages depend.

1. *Does the narrow-gauge system permit the use of sharper curves than the standard-gauge system?*

Undoubtedly, and herein lies the chief part of its economical value for railroad construction.§

With circumstances otherwise the same, that is, with the same speeds and wheel-base (distance of the axles from each other) of rolling stock, curves can be used on the narrow (meter) gauge road whose diameters are in proportion to those permissible on the standard-gauge, as 1 *to* 1½ *(nearly).*

This makes it possible for the road to go around the difficulties of the ground more easily, to fit it more closely to the elevations and depressions of the surface, and thus diminish the number and extent of the earthworks and structures, and thus it may, especially in mountainous districts, assist materially in keeping down the cost of construction.

Only we must take care, in our effort to build cheaply, not to increase the cost of operation to such a degree as to make the economy in construction wholly illusory, and even render it an irremediable disadvantage.

The ability to curve the road is limited by the relation which must exist between the wheel-base of the rolling stock and the radius of the curve, if the latter is left so that it can be run through; by the decrease of performance of the motive power on curves, due to the increase of resistance; and in the addition to the cost of maintaining the track, the guarding of the road, etc. Only in wholly exceptional cases will it be neces-

§ It must be remembered that Baron von Weber writes of railroads of the European system, with four-wheeled cars, for which a moderate curvature, or what would be so considered here, is indispensable. Actually, with American rolling stock curves are practicable with the standard gauge, and are not uncommonly used, which have less than half the minimum radius of the shortest curve on European narrow-gauge roads. The largest traffic in America, and probably the second largest in the world (about 300 trains each way daily), is done to-day without the slightest difficulty on a road of standard-gauge which has curves of 90 ft. radius.—NOTE BY TRANSLATOR.

sary to proceed to the extreme limit of what is permissible on the narrow gauge in reducing the radius of curves, and in very many of these cases the result will be that the increase of the working expenses will represent the interest on a larger capital than it would have been necessary to expend to avoid the sharp curve.

Nevertheless, the chief economical advantage of the narrow-gauge system of railroad construction consists in the permissibility of sharper curves.

2. *Does the narrow-gauge system permit the use of a steeper grade than the standard-gauge system?*

The ability to ascend grades on railroads depends on the adhesion (caused by the weight of the locomotive) of the wheels on the rails, and on the capacity of the engine for generating steam (aside from uncommon methods of locomotion).

The gauge is evidently wholly without influence on the amount of the adhesion of the wheels on the rails; but the reduction of the gauge increases the difficulty of constructing engines of as great capacity as those of standard gauge on so narrow a base, as the economy of making steam decreases rapidly with the dimensions of the steam-generator (the boiler). Hitherto the latter has been only partly attained, and that by sacrificing one of the main virtues of every mechanism, that is, simplicity (by the so-called "double-truck" engines of Fairlie, Meyer and others), and by the production of locomotive mechanisms whose complication and the difficulty of whose management make them little suited for narrow-gauge railroads especially.

But if the handling of a certain amount of traffic, by reason of the smaller capacity of the engines, must be effected by its distribution among a greater number of smaller trains, then the expenses and risks of the operation increase in the same degree as the capacity of the rolling stock decreases. The same bulk of traffic, therefore, especially if it must be moved within a certain time, can never be moved with the same economy in motive power on a narrow as on a standard-gauge road.

We will return to this subject further on.

3. *Is the saving in earthwork and masonry considerable that can be secured by reducing the gauge?*

By the indirect effect of the reduction it may be considerable, so far as it, as above mentioned, renders it possible here and there wholly to avoid or to reduce the dimensions of earthworks and structures, by permitting a line which closely follows the natural surface. The savings obtained, compared with the construction of a secondary road of standard gauge under similar circumstances, where the requirements are very unfavorable for the latter, may amount to as much as 30 per cent. of the cost of the substructure.

But as the expenditure for earthworks and structures for a standard-gauge secondary railroad, according to experience, on the average amounts to only 15 to 20 per cent. of the total cost of construction, this economical effect in fact is not so great by far as many think or pretend, and it will seldom amount to a difference of 10 per cent. in cost of construction between a standard and a narrow-gauge line *constructed to meet equal requirements.*

According to the observation of the distinguished Swedish engineer corps, which of all technical bodies in Europe has had the widest experience in the construction of secondary railroads, with the most various circumstances of surface, by reason of the considerable number of them in Sweden, made of three different narrow gauges and of the standard gauge—according to their observation the economical advantage of the narrow gauges in the direction mentioned is still less, and disappears entirely in a country which admits curves of about 1,300 ft. radius for the standard gauge.‖

4. *Does not the reduction of the gauge permit a cor-*

‖ It must be remembered that this is for European rolling stock, and that with American rolling stock curves of 300 ft. on standard-gauge roads are worked without difficulty, and even curves as low as 75 ft. radius are worked safely, though of course with great reduction of the effectiveness of motive power.—TRANSLATOR

responding reduction of the width of all structures?

At first it seems extraordinarily plausible, and even self-evident, that with a narrower gauge and nothing more a corresponding reduction of the width of all earthworks and structures must go hand in hand. This, however, is one of those fallacies to which railroad engineering only too often leads the views of laymen.

Secondary railroads of standard gauge are seldom made with a breadth of more than 10 *ft.* 8 *in. over the surface of road-bed.*

Experience has shown, however, that earthworks, in order to be always stable, able to endure the weather and economical in maintenance, must have a certain width; that, further, the distance between the rails and the angle of slope must be the same with the narrow as with the standard gauge, in order to be capable of enduring the side pressure of the track when a train passes, and not to endanger the track in case of slight washes and slides; that finally, neither ties nor ballast, if they are to give sufficient lateral stability to the track, can be shortened or lessened at will with the reduction of the gauge.¶

From these and some other causes, the discussion of which latter would lead us too far here, it has resulted that *hitherto no narrow-gauge railroad in Europe for public passenger and freight traffic has been constructed with a surface of road-bed less than* 9 *ft.* 10 *in. wide.***

So that the difference in the width of structures of roads whose gauges differ by about 30 per cent., amounts to only about 15 to 18 per cent.

Similarly, a reduction of the dimensions of the space, height and breadth of passenger-car bodies in proportion to the reduction of the gauge is prevented by the space required by the dimensions of the human body. ††

¶ See Weber: "Praxis der Secundärbahnen," etc., p. 29.

** Even the Festiniog Railway, whose gauge is only 23½ in., is made with this width of road-bed.

†† See Weber: "Praxis der Secundärbahnen," p. 64, etc.

Every man who has worked a railroad knows further that with a reduction of the dimensions of the bodies of the freight cars, the facility of disposing of the freight in them—the economical utilization of them—is reduced, so that certain staples of traffic of customary dimensions (such as bales of wool, certain boxed goods, casks, etc.), and especially live stock, absolutely require certain dimensions in the car-body, which forbid their reduction in proportion to the gauge. Thus again the result has been that the dimensions of the rolling stock on all narrow-gauge roads that have been built have been considerably greater than would have been proportional to the reduction of the gauge. From this again it follows as a consequence that where the narrow gauge is adopted, only a moderate percentage of the saving in tunnels, cuttings, viaducts, structures, etc., can be attained, that might have been expected from the reduction of the gauge.

5. *Is there any saving to be effected in the superstructure of narrow-gauge roads in comparison with the standard gauge?*

We have just laid down the chief elements which have caused that greater dimensions in the breadth, height and space must be given to the rolling stock of narrow-gauge railroads than would naturally occur by the lessening of the gauge.

This means, to speak so as to be generally understood, a relatively much larger and higher car-body on a much narrower base on the narrow gauge than on the standard gauge.

The natural consequence of this is that every inequality, depression, deviation, on the narrower foundation must cause a much greater oscillation of the higher, larger, heavier car-body than in the broader base of the standard gauge, while on the other hand the oscillations of these vehicles must have a much more destructive effect on the narrow superstructure than those of the cars of standard-gauge roads. This reciprocal effect increases the demands on the superstruc-

ture as well as on the cars. It follows from this, again, that, in order to secure equal safety and comfort, and equal economy in motive power in operation, the running trains being the same, the superstructure of the narrow-gauge roads must be made relatively stronger and must be much better maintained than that of standard-gauge roads, and especially because on the sharper curves of the narrow-gauge roads with equal speed, the danger of derailment is greater (because of the centrifugal force and the greater effect of the play of the wheels on the track) than on the easier curves of the standard roads.

Therefore on the narrow-gauge roads that have been constructed, longer ties, heavier rails, deeper ballast, etc., have been used than was to have been expected, *a priori*, as proportioned to the gauge and requirements of traffic. This truth is shown most clearly by the road of narrowest gauge (23½ in.) that exists—the Festiniog Railway in Wales, on which the weight of rails has been increased from 15 to 50 lbs. per yard, whose ballast had to be raised to the thickness of 2 ft., whose ties are double the width of the gauge in length, and are as broad and thick as those of main roads, and whose rail joints have to be provided with the strongest kind of fish-plates, in order that the track may be kept in condition to be run over.

Nowhere has the maintenance of the narrow-gauge track proved in practice to be cheaper than that of the standard gauge, very often dearer; on the average always dearer, when the quantity moved is taken into consideration.‡‡

It is evident that with the narrow gauge the station yards (since here the dimensions of rolling stock and the radii of curves govern) diminish somewhat, though not entirely in proportion to the reduction of the gauge, and with them the sometimes considerable cost of such grounds; that the turn-tables and transfer-tables are smaller and cheaper, while in the price of the switches there is no difference worth mention. The other ex-

‡‡ Weber: "Praxis," p. 38.

penditures for establishing stations remain, if the demands on them are similar, the same for both systems, save a slight reduction of the dimensions of structures for the operation of the narrow gauge. For the narrow gauge there are added the cost of the often costly over-head tracks for dumping cars, inclined planes, cranes, and other apparatus serving for the transfer of freight.

As to cost of right of way, which, however, except under extraordinary circumstances, forms but a relatively small part of the cost of construction, especially in mountain country, the special field for secondary roads, the narrow gauge may sometimes exercise a favorable influence, since it facilitates the avoidance by means of curves of what would be costly to buy; but here again there is always danger that the operation will be injured more than the construction will be benefited.

Although in what precedes we have adduced only the chief points of view which the experience of the secondary railroads completed in Europe present for the comparison of the relative economical peculiarities of the standard-gauge and the narrow-gauge systems, yet from these will be recognized the sufficient grounds of the final conclusion of that comparison, based only upon facts.

The construction of a secondary railroad line will require on the whole nearly the same expenditures, assuming that the requirements on it by the bulk, form, speed, frequency and nature of the traffic are the same, whether it is made with the narrow or the standard gauge (although the cost of the substructure, superstructure, stations, etc., differ), and for this reason, that the greater cost of superstructure and the less cost of substructure on the narrow-gauge nearly equalize its cost with that of the standard-gauge.

6. *Is the rolling stock cheaper for a narrow or for a standard-gauge road?*

The answer to this, again, can only be made under the assumption that equal requirements as to speed and

bulk of traffic are made on the roads to be compared. The capacity of the single vehicle of a narrow-gauge road is less than that of the corresponding vehicle on the standard gauge. Its parts are weaker and smaller, but the number of them is the same, and therefore the labor in making one is nearly the same, though the quantity of material is less. Two cars, each of 11,000 lbs. capacity, therefore, cost not only as much as one of 22,000 lbs., but far more.

Since, now, for the same service on a narrow-gauge road a greater number of cars is necessary than on the standard-gauge road, so also is the cost of the car equipment sufficient for the same traffic on the standard and narrow-gauge road considerably higher on the latter than on the former.

The case is the same with the repairs and renewals of the cars, the expenditure for which is determined less by the size and weight of the parts than by their number, as is known to every mechanic of moderate experience. Further, two cars of 11,000 lbs. capacity weigh not only as much as one of 22,000 lbs. capacity, but very much more : indeed, one of the latter is not much heavier than one of the former. On this depends the progress of all economy in transportation, that the traffic be forwarded in the smallest possible number of cars of the greatest possible capacity, and thus the dead weight of the cars be decreased in proportion to the weight of the freight.

Now, on the narrow-gauge road the same traffic is divided among many more cars of smaller capacity, whose total weight is far greater than that of the cars for the same service on the standard-gauge road ; thus the economy of transportation is considerably more disadvantageous on the narrow than on the standard-gauge road.

Likewise, it is difficult to secure a satisfactory utilization of the passenger cars of the narrow-gauge roads, which afford little accommodation. Nearly the same phenomenon appears with regard to the effectiveness of the locomotive.

As has been said above, hitherto the builders have not been successful in constructing locomotives for narrow-gauge roads whose economy in performance, for the same requirements, is equal to those of standard-gauge roads, since this economy, as remarked above, depends chiefly on the size of the steam-generators, which cannot be carried so far on the narrow as on the standard-gauge road.

The transportation of the same load with one powerful, instead of two weak engines, costs much less for fuel, wear, maintenance, repairs, etc., aside from the fact that two smaller engines which do the same work as one large one, costs much more than the latter.

Thus in regard to economy of motive power also the narrow-gauge road cannot equal the standard-gauge.

Experience in the operation of those European narrow-gauge roads which carry passengers and freight has afforded these conclusions to our hands, and by the high figures of their total working expenses has established this fact : *that hitherto efforts have not succeeded in rendering the operation of the narrow-gauge roads cheaper than that of the standard-gauge roads ; that indeed in most cases the former fall behind the latter in economy.*

The question of the economy in equipping the two systems takes a wholly different phase, however, when we take into consideration the fact that on the standard-gauge secondary road, whose traffic naturally can be carried at much lower speed than that of the main road, the whole equipment of locomotives, passenger and freight cars, turn-tables, switches, transfer-tables, etc., which have become inadequate to the amount and speed of the service on the main line, and in construction have fallen behind the times, can find employment for many years, being perfectly well calculated in regard to economy, construction and safety, for the slow service of the secondary road.

The great roads find daily fewer and fewer chances for

employing and utilizing this material, whose cost has often been already charged off from the books of the companies; and for lack of employment it is offered for sale at trifling prices, to be broken up for the old materials.

Equipment with such material, which but recently was sufficient for the traffic of Europe, will always answer the purposes of the secondary railroads, and have the immense advantage that the proper material for increasing it is always at hand, that the shops of the main lines possess the tools required for maintaining it and the models of its parts, that finally the officers and employés going from the main to the secondary roads are familiar with its every detail, and know how to manage it.

While thus the provision of the equipment may be effected with a true minimum of expense, the main line which undertakes the secondary road has the ability to conduct its operation at a decidedly cheaper rate, since the secondary road affords it an opportunity to utilize its equipment to the utmost. The advantage will be attained, in regard to economy not enough valued, of a rational, actual "using up" of costly material, whose value now is lost by its removal from the operation of the main roads to be broken up; while still a considerable amount of service can be obtained from it by its use on roads of subordinate rank.

The equipment with the material of the connecting roads, moreover, secures to the standard-gauge secondary roads the advantage that they need be provided only with equipment enough for their average amount of traffic, since in case there is an extraordinary pressure of traffic, the main line can assist it with its entire rolling stock, which in every respect is suited to the ~~narrow-gauge~~ secondary road. If now for the through traffic over the main line a suitable share of the latter's rolling stock is added to that of the secondary road (and it is perfectly available in the latter's slower trains), then the equipment of the secondary road is effected in a way which satisfies economy in the construction ac-

count as well as in operating, together with the requirements of the relation with the main road, and all so as to suit the objects of both equally well.

The picture which shows the cost of providing and the economy of working the rolling stock on a narrow-gauge road is a wholly different one.

The latter must be designed in accordance with the dimensions and peculiarities of the road, and constructed new throughout. The cost of providing the rolling stock of a narrow-gauge road would, as we have shown above, assuming equal requirements, come to more than that of a standard-gauge road, even if the latter also had to be bought new.

Under these assumptions, which are almost always realized, the difference against the narrow-gauge becomes a truly enormous one, calculated to cast into the shade any advantage which the economy of construction of a narrow-gauge road can possibly offer.

To this must be added that all the apparatus connected with the operation, such as turn-tables, water cranes, transfer-tables, switches, etc., must all be provided for the narrow-gauge after new models ; that the workshops must have different arrangements from those of standard-gauge roads, and the tools for manipulating and repairing the parts must be different ; that the employés must make themselves familiar with an entirely new set of railroad appliances, whose peculiarities are grasped only after long experience ; that, finally, there can be no, or scarcely any, thought of coöperation between the narrow-gauge road and the connecting standard-gauge road by the loaning of spare parts, models, etc.

It is of much greater weight, however, that the narrow-gauge road can receive no assistance from the rolling stock of the connecting road, and, therefore, if it is to fulfill its objects, must be itself provided with an equipment sufficient for its maximum traffic, only offered occasionally, and which therefore must be much beyond the proper average need of the road, and so burden it with loss of interest on capital.

In discussions of the gauge to be given this or that road, which was to be constructed over difficult ground, this necessity of providing a wholly new equipment after models of a new system, different tools, shop apparatus, operating appliances, etc., in many cases has been decisive against the narrow-gauge, as evidently the construction and the working of the road would have been made costlier thereby, aside from the isolation of the line from any assistance from the connecting main roads.

In fact, the greater expenditure required for the new equipment of a narrow-gauge road with a stock sufficient for its maximum requirements, in comparison with the cost of an equal provision for a standard-gauge road which uses the worn material of the main lines, in almost all cases considerably exceeds the saving in construction due to the adoption of the narrow-gauge; and it certainly always does so in those cases where the country on the line is not extremely difficult and the development of the economical peculiarities of the narrow-gauge system is not exceptionally favorable.

III.

ECONOMY IN WORKING.

Having in the foregoing described the advantages which, each in its way, the standard-gauge and the narrow-gauge systems offer in regard to economy of construction and equipment, there still remains for us only to answer a few questions on the circumstances which exercise an influence on the economy of working secondary lines of both systems, and which have not yet been touched upon in the foregoing.

Here also we have adhered firmly to the results of experience.

7. *How is it with the utilization of the rolling stock on secondary railroads of the two systems?*

If standard-gauge secondary roads were worked with the speed of the main lines, then naturally the utilization of their freight cars would be on the average

nearly the same as on main lines, that is, not far from 40 per cent. of their capacity.

The proportion, however, is greater, on account of the lower speed of secondary roads; since this lower speed permits the cars, at least for the local traffic of the road, to be more heavily loaded than would otherwise be admissible. Moreover, the nature of the traffic which prevails on secondary roads, consisting chiefly of raw materials, for which the time of delivery is usually little restricted, makes it practicable to wait for full loads, etc.

Those cars which run through on the main lines naturally can only receive the load which is permissible on the latter.

The ordinary dimensions of the car bodies and platforms, however, make this profitable heavier load for the slow local traffic practicable only with certain traffic staples, such as ore, some kinds of coal, metals, salt, certain kinds of grains, timber, stone, etc.

By the inability of its cars to run over roads worked with fast trains the narrow-gauge system secures the advantage, that all its cars may be constructed for the greater load at the lower speed.

On roads destined solely for carrying produce (to the exclusion of passengers), for this reason a proportion between weight of car and of car-load may be attained more favorable than can ever be reached on main roads, which would reduce the transportation expenses to a minimum.

This is impracticable upon narrow-gauge roads on which, together with the freight traffic, and even mixed with it and with equal privileges, a passenger traffic is conducted. The speed of all the trains suited to such a traffic then must not be fixed below 12 miles an hour, if it is not the direct intention to constitute a secondary road for slow trains (7 miles an hour), on which evidently the passenger traffic can have only a wholly subordinate importance. Roads of this system, moreover, are not meant by the Government programme for secondary roads. In this case a still fur-

ther increase of the capacity of the cars will be possible; but this will, at best, only partly balance the uneconomical influence of the above-mentioned division of the traffic among a greater number of cars, caused by the narrow-gauge.

To an eminent degree the constructor of the rolling stock of a narrow-gauge road will be supported in his efforts for economy, improvement and the establishment of a more favorable proportion between live and dead weight by his ability to give them a simpler construction than on main lines (central buffer system, etc).§§

But all these aids can serve only to modify somewhat the influence of the greater division of the traffic, *and the experience of all narrow-gauge roads operated in Europe, that carry both freight and passengers, has shown that the utilization of the freight cars on them is in no degree more favorable than on the standard-gauge roads.*‖‖

8. *How is it with the transfer of the traffic from secondary roads of the two systems to the main line, and its cost?*

Evidently the traffic of a standard-gauge secondary road is exchanged with that of the main line without delay and without other cost than what is connected with the delivery and receipt of foreign traffic. If the secondary road is worked by the main line, even this disappears.

It is otherwise with the narrow-gauge road, which requires the reloading of the traffic to and from the main line.

This reloading is effected, according to the nature of the freight, in different ways and at different rates of cost.

Ores and those coals which can bear it may be dumped from the cars of the narrow-gauge road, after

§§ Weber: "Praxis," p. 78.
In Europe cars have two buffers at each end; the central buffer system is used universally on standard-gauge roads in America.—THE TRANSLATOR.

‖‖ Weber: "Praxis," p. 25.

having been run up on a species of bridge structure over the tracks of the standard-gauge road, into the cars of the latter.

The cost of this method of transfer is very small, and is limited almost wholly to the provision of the dumping apparatus.

The matter becomes more difficult when such materials pass from the main road to the narrow-gauge, when the reloading must be done with the shovel, or at least with the scraper.

In this case the expense of unloading becomes as great as that of a considerable haul.

Stone, boxes, bales, bar-iron, casks, etc., etc., must be transferred by hoisting apparatus or by hand, and their new arrangement in the cars to which they are transferred absorbs time and labor. The reloading by itself is here quite costly, but it would be much less considered if its cost was not increased directly and indirectly by various circumstances. Among these belong the expenditures for the tracks on which the cars have to stand during the transfer; for the buildings where the manipulation can be made under shelter; for cranes, scales, etc.; for office expenses connected with the renewed weighing, sorting and entering of the shipments, since the loads have to be divided in the large main line cars otherwise than in the small narrow-gauge cars; for losses in labor and in the interest on the cost of the cars, which must often remain standing a considerable time at the transfer stations, before they can be loaded or unloaded; for superintendence, switching, cleaning snow, etc., at the transfer stations, etc., etc.

Of these expenditures, which are scarcely mentioned by the extreme advocates of the narrow-gauge system in connection with the bare cost of the labor of reloading, the latter forms only a very small percentage; and the statement that at this or that station such or such a trifle is paid per hundred pounds in the wages of the labor employed for reloading gives a totally false idea of what it actually costs.

But even the whole sum of the expenditures required by the reloading is of less importance than the economical dangers which are connected with the transfer of the articles carried from one gauge to the other.

Most of these articles are in danger of being more or less damaged, or of deteriorating in quality, by the reloading; none of them gain by it. Bales of goods get wet or burst; boxes and pieces of machinery break; corners of furniture, cut stone and terra cotta are knocked off; casks leak; even bricks and drain-tiles lose their customary angles; slates are broken, etc. The possibility of the occurrence of such injuries has, for example, caused the Belgian merchants to avoid shipping all the more valuable freights from Antwerp to Ghent by the direct narrow-gauge railroad between these two cities, and to bear the cost of the circuit by way of Mechlin, solely in order that the goods may not be reloaded.

There are, in fact, only a very few kinds of freight which do not suffer some reduction in value by reloading, and the amount of it would often outweigh the transportation a far greater distance, and sometimes it is too great for comparison.

Ores, materials for roads, timber, and certain kinds of very hard coal, and such as lose nothing in value by being broken (like various English, Belgian and Westphalian coals), suffer no deterioration at all.

On the other hand, every loading or unloading, whether by dumping or shoveling, reduces the value of all Bohemian, Moravian, Austrian and Styrian brown coals and lignites to so great a degree that it is almost inadmissible.

The pecuniary disadvantage, the economical injury, which is due to the reloading of the freight at the transfer from one road to another of different gauge therefrom does not consist solely in expenditure for unproductive labor and time in the reloading itself, in the cost of establishing transfer apparatus, tracks and space, in the delay of the shipment, and the loss of in-

terest on capital and of service during the waiting of the cars at the junction stations; but, by far the greater part, in the dangers to which most kinds of freight are exposed in reloading, and in the reduction of value which they suffer therefrom.

Recently an eminent North German railroad engineer, under whose auspices a little narrow-gauge railroad is to be constructed, recognizing these evils perfectly, has made an attempt to construct rolling stock for it, by which the reloading is to be avoided by transferring (sliding) the entire car-bodies of the roads of different gauges upon trucks arranged for that purpose.¶¶ That this extremely ingenious idea can be applied only within very narrow limits, since it requires for its manipulation arrangements on the standard-gauge freight cars which they do not all possess, is evident. It is impossible to state generally in figures the amount of the disadvantages due to reloading; indeed it is not the same at different junctions for the bare wages of labor and for the same kind of freight.

The same heavy block of stone whose transfer at a great Paris or London station, provided with hydraulic loading apparatus, costs almost nothing, at a little junction station has to be laboriously and slowly moved by rollers and levers from car to car. In this case, perhaps, its transfer costs as much as the whole cost of transportation on the rails.

Wages of labor, instruction of the employés, apparatus for handling, local circumstances, weather, season, etc., etc., will always cause the cost and risk of reloading to vary within wide limits, so that its value in money can never be expressed *a priori*.

The distance the transferred freight is carried has no effect on the cost of transfer. This cost forms a constant amount in the total transportation expenses.

¶¶ Something of the same kind is commonly practiced in this country at junctions of 6 ft. and 5 ft. gauge roads with those of standard gauge. It cannot be applied to transfers to and from 3 ft.-gauge roads to the same extent; car-bodies of that gauge can be transferred to standard-gauge trucks, but standard-gauge car-bodies cannot safely be carried on 3 ft.-gauge trucks.—THE TRANSLATOR.

Therefore it burdens short hauls very heavily, and almost disappears on very long ones. The great narrow-gauge systems in America, Asia and Australia, therefore, scarcely feel at all the pecuniary influence of their connection with quite as large systems of a different gauge; while with lines only a few miles long, with light traffic and small earnings, like most of the secondary roads which are now being constructed in Europe, it exercises a very depressing effect, and, should costly payments have to be made for damages a few times, it may actually become overwhelming. This also shows how irrational it is to compare the two systems on general principles, and to adduce results obtained in the construction and operation of roads of one system under certain circumstances as decisive under entirely different circumstances at another place.

9. *Are the reciprocal effects of the passenger traffic between two roads of different gauges as complicated as those of the freight traffic?*

Not at all. Man is an article of traffic which transfers itself from road to road without cost, though not without trouble. The transfer of passenger traffic from road to road is substantially the same, whether they have the same gauge or not. The transfer of passenger *cars* from road to road, which is often very desirable but is not at all necessary in the interchange of traffic between main and secondary lines, of course is prevented by difference in gauge. Since the rolling stock of the main roads, or equipment suited to them, can be used on standard-gauge secondary roads, on them the passenger finds his accustomed accommodations in full measure. Where it is decided to construct new passenger cars*** for secondary roads it will be advisable to resort to the American system of construction, with movable trucks, longitudinal passages

*** The passenger cars which are almost universally used in Europe are supported on four or six wheels whose axles are fixed rigidly to the car-bodies, and the cars have their entrances at the sides, while the seats run entirely across the car, so that there must be a door (usually one on each side) for every two seats, which seats face each other.—THE TRANSLATOR.

through the middle of the cars, and entrances at the ends, as these offer great advantages in local traffic for short journeys (especially by day).

The railroad with the narrowest gauge—the Festiniog Railway in Wales—uses cars of this construction successfully, while the narrow-gauge roads of Belgium, Norway, Sweden and Germany use compartment cars. However the first method of construction is the best for secondary roads, the other is fully justified for such roads of standard gauge on account of its utilizing the worn equipment of the main lines.†††

Hitherto builders have not succeeded in constructing passenger cars for narrow-gauge roads in which there was not either an imperfect economy of space, and therefore a comparatively large dead weight per passenger, or an arrangement which affords a less accommodation to the passengers than that given by the standard-gauge cars.

On the only narrow-gauge system in Europe, the Norwegian, whose length is sufficient to permit real journeys on it, and whose cars, therefore, have to provide accommodation for journeys, which is a very different thing from accommodation for trips of a few miles in the day-time, the problem has been solved as well as is generally possible ; and there, as on the Antwerp & Ghent road, the width and height of the cars have been made greater than is in proportion to the narrow gauge. Therefore very excellent and costly maintenance of the track is necessary in order to give these cars, with their high centre of gravity and load extending far beyond the rails, a steady motion. In spite of these maximum dimensions the passengers on the Norwegian roads have to content themselves with 19 in. width of seat in the first-class and 16 in. in the second-class cars (there are only two classes), and with a very restricted space for the knees, which to the

††† A few Austrian railroads run cars of the American system for local traffic, even on main lines. These would suit admirably for a long time yet for the working of secondary roads. One such car in the train, with compartments for the second and third classes, will in most cases fully answer all requirements.

public accustomed to the railroads of the European continent would be very distasteful. The use of only two classes is generally advisable for secondary roads of this system.

On the whole, the arrangement and accommodation are matters of relatively slight importance on secondary railroads of both gauges, of the kind now under consideration, on which the journey would be in the day-time only, and last only a few hours. Therefore neither system has much advantage over the other in this respect, as the simple requirements of a provincial local traffic can be satisfied by either.

10. *In the choice of gauge, should not some regard be had to the possibility of the secondary roads having to meet military requirements?*

Certainly it is not entirely labor thrown away, in the choice of a gauge for certain roads, to inquire whether, by the establishing of connections in this or that direction, or possible strategic dispositions, a secondary line may become of some military importance (as for a line of supply), even if subordinate and temporary.

To show circumstantially why narrow-gauge roads can have as good as no capacity for military purposes would lead us too far here.‡‡‡

We must refer those who seek for further information on this point to the subjoined summary of the literature on the subject. They are chiefly prevented from the effective performance of military service by the dimensions of their cars, which neither permit the economical stowing of horses nor of wagons and artillery, nor of men loaded with their equipments. In case the investigation should indicate the above-mentioned possibility, therefore, it will be advisable, even at the public expense, to make the roads useful for military purposes, at least in case of need, by constructing them with the standard-gauge; especially as the military capacity of single-track main roads even remains always limited and doubtful.

‡‡‡ Weber: "Praxis," p. 117

IV.

FINAL CONCLUSIONS.

11 *a. In what cases and under what specific requirements is the standard-gauge system to be preferred for the construction of secondary roads?*

a. When the saving in construction attained by the adoption of curves permissible only on the narrow-gauge is not great enough to outweigh the advantages which the standard-gauge secures by cheapness of maintenance of way and of equipment with rolling stock, the avoidance of reloading, and the greater economy of operation.

b. When the traffic of the road in question is a mixed one of both passengers and freight, neither of which so decidedly exceeds the other that the road may be made specially a passenger or specially a freight road: an example of the first is the narrow-gauge road from Lausanne to Echellens, in Switzerland; of the second, the Bröhlthal road.

c. When the bulk of the articles carried, which pass from the secondary road to another road, and form a material part of the total traffic of the former, are of such a nature that they either experience a considerable loss in value (as, for example, nearly all Austrian coals from reloading: or are costly to transfer, and require for such reloading the provision of considerable apparatus; or, finally, are subject to considerable risk from reloading.

d. When the secondary road is of very moderate length, so that the transfer expenses form a considerable percentage of the total expenses of the through transportation.

e. When the transfers from the secondary road to the main road exceed the local traffic of the former, and do not consist of articles whose transfer, rightly managed, occasions almost no expense and no reduction in value.

f. When the bulk of the traffic passes from the main road to the secondary road, and not *vice versâ*.

g. When a considerable part of the traffic consists of articles which can only with difficulty and danger be hauled round the sharp curves of the narrow-gauge roads, or is uneconomical for such roads. Such articles are cattle, for which narrow-gauge cars afford no accommodation, long rolled iron, such as beams, rails, etc., but especially timber, which the effect of traction on very sharp curves forces too powerfully and to a dangerous extent in the direction of the chord of the arc.

h. When there is a possibility, though but distant, that the secondary road, by connections or the increase of its own importance, must be changed sooner or later into a road with faster traffic, including mixed trains of various characters and speeds.

i. When it is possible that the secondary road may have to answer military purposes of any kind.

11 *b. Similarly, in what cases is the adoption of the narrow-gauge advisable, or equally so as the standard gauge?*

a. When, as is the case in Canada, East India, Australia, Norway, etc., the system of narrow-gauge roads is so extended and its own internal traffic so great, that the connections with adjoining systems of different gauge become comparatively unimportant, and the transfer expenses, etc., sink to a minimum amount when distributed over the total traffic.

b. When the traffic of the secondary roads is, in general terms, only raw materials or only passengers.

A mixed traffic, especially if composed of passengers, package goods and raw materials, makes the operation of the narrow-gauge costly, on account of the variety of the objects to be provided for.

c. When the reduction of the cost of construction attained by the adoption of sharp curves is so considerable that the interest on it outweighs, financially, all the economical advantages which the operation of the standard-gauge road has over that of the narrow-gauge road.

d. When the articles transferred are and will remain

those whose reloading incurs no considerable expense, no reduction in value, and no risk. Among them is, as has been mentioned, scarcely anything except ores, timber, lime, materials for road construction, undressed quarry stone, and a few kinds of coal which are scarcely ever carried in Austria.

But if the traffic in such articles is from the main to the secondary road, then the methods of cheap transfer, dumping apparatus, etc., are hardly applicable, and the adoption of the narrow-gauge is no longer advisable.

e. When the nature and dimensions of the narrow-gauge cars make it practicable for them to penetrate to original source of the object to be carried—into the adits of mines, to working shafts, into quarries, pits, forests, etc.—so that they can transport their loads untouched thence to the point of transfer.

f. When a system of roads is completely isolated by natural barriers (on islands, where the only outlet is by water, etc.).

Still here we should proceed cautiously, as the example of the Swedish roads, cited above, shows.

g. When the country roads and highways can be used with great advantage as routes of secondary roads (as was the case with the Bröhlthal road), and the width and turns of these highways make the application of the standard-gauge too difficult and costly.

12. *In what cases is the adoption of the narrow-gauge system decidedly unadvisable?*

a. When a mixed traffic of passengers, package goods and produce makes it probable that, in accordance with experience, the working expenses of the narrow-gauge road will be so high that it will be difficult to meet them, and a suitable income on the capital of the road becomes almost impossible.

b. When many junctions with main roads may be necessary, or a system is so located that its change into a system of higher rank may be required.

c. When the requirements of the traffic vary greatly, so that provision for the maximum business must be

made by a costly equipment, which in dull times must stand still, a non-productive and even wasteful property, since the narrow-gauge road is unable to send its cars over other roads.

If, in conclusion, we turn our attention to what actual results the numerous discussions, investigations and observations have led, which for more than half a generation have been made with regard to the gauge of secondary roads in all countries in Europe where railroads are highly developed, the quintessence of which we have spread before the public in the foregoing—if we turn our attention to these actual results, we find that in England the much studied Festiniog Railway has had no successor; that in Belgium the Antwerp & Ghent line not only has remained isolated, but will probably be rebuilt; that in the Rhine country, Westphalia and Upper Silesia the narrow-gauge system has had no extension for public service; finally, that in Sweden (which of all European countries has had opportunity to make the most experiments with the narrow-gauge system), the system has been abandoned on principle for all lines of mixed traffic.

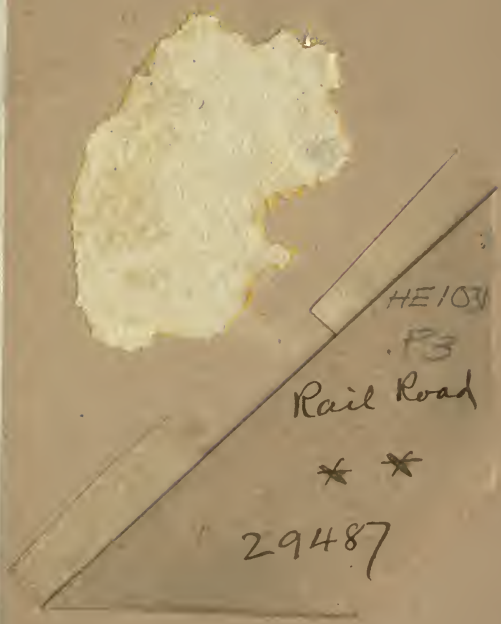
Against the weight of these plain-speaking facts one weak voice is raised, that France, apparently, has here and there begun to construct narrow-gauge secondary roads, if even this phenomenon were the consequence of persuasion of the fitness of the system for the objects in question. But in fact, it is almost wholly an emanation from the tendency which prevails in the controlling circles, and which has come down from the Napoleonic *régime*, to protect the financial interests of the great "railroad monopolies" at any price, and even from the most remote possibility of competition, to which tendency is due a part of the regulations of the law of 1865 concerning railroads of local interest.

The new short narrow-gauge roads of Switzerland have arisen under circumstances for which we have had to designate them as most suitable under 11 *a* and 11 *b*.

It is not difficult to draw the proper conclusion from what has been said, and to apply it properly to the programme for the construction of secondary roads in Austria which has just been submitted. No technical knowledge is required for this, but only a sound understanding and a really honest purpose.

Both can and will be found in the controlling circles, and so it is to be hoped that Austria will remain secure against increasing by one the number of colossal experiments from whose success the welfare of this glorious country, in peace and war, is expected.§§§

§§§ There follows a list of 55 different works and articles on narrow-gauge railroads. in German, English, French, Spanish, Italian, Norwegian and Swedish, which have been studied by the author, besides the notes of his personal examination of most of the light railroads of Europe.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